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Method for Heat Treating Metallic Extrusion Billets

The invention relates to methods for heat treating metallic billets or - when hot shears are used - rod portions, before they are fed into the extruder, as well as devices for performing said method.

In the following, such extrusion billets or rods are also described as "blocks".

Cast, homogenized and subsequently cooled blocks are exposed to a heat treatment directly before being fed into the extruding device, in which treatment the blocks are reheated, then cooled and delivered to the extruding device.

Such a method follows for example from EP-B1-0 302 623. Here, a conventionally cast extrusion block, principally made of an aluminum-magnesium-silicon alloy, is first homogenized and cooled after the casting process, in accordance with the prior art. Before being pressed, it is heated to a temperature above the solubility temperature of the phases separated out during cooling and after homogenization, and kept at this temperature until the phases are re-dispersed. After being reheated, wherein the block is at a temperature of more than 350°C for at most 20 minutes, the block is quickly cooled down to the extrusion temperature, which is lower than the solubility temperature and is at most 510°C. This cooling is intended to prevent the phases from separating out again.

Aside from the fact that it can hardly be technically possible in a production plant geared for high throughput to wait until all the phases are re-dispersed, and the fact that the holding time here is limited to a period of time of less than 20 minutes which puts doubt on the dispersion of the separated phases, this method is not suitable to be employed in a heat treatment process taking place before the actual extrusion process using a high-production extruder.

It follows from the description that in the method according to EP-B1-0 302 623, the cooling process for reaching the lowest cooling temperature lasts up to 20

minutes. This is therefore a process which is over in a matter of minutes and in which the temperature can be equalized even over larger distances by thermal conduction, i.e. also noticeably in the longitudinal direction of the block. This is the reason why only one temperature is mentioned in each case in the aforementioned specification.

Such, only moderately rapid cooling is disadvantageous, however, if the cooling before pressing is supposed to achieve a temperature profile which falls off in the extrusion direction - a so-called temperature taper - in the block, because when cooling is relatively slow, then the temperature is also significantly equalized in the longitudinal direction, which makes generating the desired temperature taper with the aid of controlled cooling more difficult or impossible. In direct-operation extruders, however, such a temperature taper is a precondition of advantageous, isothermal extruding.

The main purpose of the method presented in EP-B1-0 302 623 is to improve the quality of the extruder products while simultaneously increasing the rate of extrusion. To exemplify this advantage, examples are described in the aforementioned specification. There, a method according to the prior art is compared with the method according to EP-B1-0 302 623. However, with respect both to the surface properties and the stability values, i.e. RPO 2, RM and stretching, consideration of the mean variation of the technical readings does not establish any noticeably positive effect when using this method. This is not surprising, since experience has shown that in extruders, in particular high-production extruders of light metal alloys, it depends very much on guiding the temperature most exactly. With respect to such temperature guiding, however, the aforementioned specification contains no details of what temperature precision is required nor of how this precision is to be achieved.

Other citations deal with heating such blocks on the one hand, and cooling them off on the other hand.

Thus, a device for heating extrusion billets and rod portions is described in WO 83/02661, in which the surface of the material is fired with burners and/or jets of hot gas generated by combustion. The exhaust gas is collected by an exhaust gas conduit directed above the heating area and supplied by convectional heat transfer to a preheating zone. The heated material is convectionally transferred by blowing the heat using laterally arranged slotted nozzles, the flow of gas feeding said slotted nozzles being circulated in a closed circuit by fans. This device is only partially suitable for heating to narrow temperature tolerances at high throughput, since the temperature precision which can be achieved by direct firing leaves something to be desired even at moderate throughputs. The capacity for regulating the temperature is negatively influenced by the fact that the exhaust gas collecting conduit consistently removes the exhaust gas in the same way, independent of the heat input and therefore of the localized production of exhaust gas in a particular area of the device. A further disadvantage is that convectional heating, which in principle is more uniform than heating by direct firing, is used at the beginning of the device where high temperature precision is not particularly important because the material temperatures there are still low, while at the end of the heating process, where only slight differences in temperature can be tolerated, the product is heated exclusively by direct firing, which due to the method leads to large, localized differences in temperature. The device in accordance with WO 83/02661 is therefore designed unfavorably, namely the wrong way round, for the purpose of heating precision.

In order to better exploit the hot exhaust gases of the heating zone, which for example uses direct firing, a device is described in DE-OS 26 37 646 in which the hot exhaust gas is circulated in convectional heating zones in the material transport direction, before the rapid heating part using firing, and blown onto the material using jets before it leaves the device through the exhaust chimney. The nozzles are slotted nozzles arranged on both sides of the material, whose nozzle openings have longitudinal axes perpendicular to the axis of the material. This device also exhibits the unfavorable arrangement, with respect to uniform heating, of the convectional heating zone before the heating zone using direct firing.

Other devices using convectional heating without any direct firing of the material are known from DE-OS 35 09 483 A1, DE 34 18 603 C1 and DE 195 38 364 C2. In these devices, the flow of gas circulated in the convectional zones for the purpose of convectional heat transfer is heated using heating means, and the heat is transferred by said flow of gas onto the material.

All these devices exhibit significant disadvantages. Uniform heating having a sufficiently uniform temperature distribution can indeed be achieved in the devices using convectional heating without direct firing; however, limiting the operational temperature to the maximum temperature acceptable to a convectional system fitted with a hot gas fan limits the maximum heat flow density which can be transferred onto the surface of the material and therefore limits the rate of heating. The result is relatively small throughputs or long plants having the known disadvantages of relatively long columns of material when changing alloys during production, which generally also require changing the end temperature of the material. This makes such devices inflexible in operational production and unsuitable for performing methods which require high precision. Other disadvantages are the higher costs due to the greater length, and larger space requirement.

Devices which heat by direct firing do permit very high rates of heating through the high oven space temperature - in devices for heating light metal alloys, around 1000°C - however the temperature distribution in the material is very non-uniform. In particular in the case of a changing surface of the material, a satisfactory temperature uniformity cannot be achieved, even with expensive control systems and regulating technology, due to the strong, changing radiation effect. When the production line is stopped suddenly, e.g. because of a extruding or instrument problem, the heated material often melts. Moreover, energy utilization is slight and the heating and energy requirement relating to the throughput of material is consequently high.

These disadvantages are also present in the device known from DE-OS 26 37 646 comprising convectional preheating. The energy utilization is indeed better, due to linking the preheating with the rapid heating, e.g. direct firing: there is only exhaust gas when firing is used, although regulating the temperature is even more difficult as a result and the temperature precision in the material is unsatisfactory, in particular when there are interruptions in production, for example when an instrument is changed. Thus, such a device cannot be employed if particular demands have to be made on the temperature uniformity, such as for example when heating aluminum alloys AlMgSi to extrusion temperatures in the homogenization temperature range and near the melting temperature and then rapidly cooling before extrusion, for the purpose of increasing productivity and quality.

A series of cooling means for performing the cooling process are known. US-A 5,027,634 describes a cooling means consisting of at least one cooling ring through which the block is pushed by means of a pushing means during the cooling process. By changing the rate of pushing, the cooling effected by the cooling means can be influenced along the length of the block. The cooling ring itself comprises numerous bores of a relatively small diameter, through which the water used as the cooling fluid is sprayed onto the block. The cooling ring is open at the top, for the pushing means to pass through. The disadvantages of this device, apart from the complicated control systems for the movements of the block and the expensive transport mechanism, are in particular the small cooling nozzles which easily tend to block up, and the uneven cooling effect around the circumference due to the opening at the top of the cooling ring for the pushing means to pass through, as there are no cooling nozzles in this area.

The device according to US-A 5,425,386 attempts to avoid the disadvantage of the small bores in the cooling ring by using an annular slot as a nozzle opening. The complicated transport mechanism and the expensive control systems for the movements of the block are, however, still required. Moreover, the annular slot as the nozzle opening is provided with the cooling fluid from an antechamber, such

that the same pressure is available around the circumference of the whole nozzle slot. There is therefore no way of adapting cooling to the requirements of the orientation of the block surface. During a considerable part of the cooling process, the temperature of the block surface is well above the Leidenfrost temperature, such that the cooling process is determined by the film of vapor immediately on the surface of the block. When the block is positioned horizontally, this film of vapor is different on the lower face, on the upper face and on both sides of the block, where the tangent runs vertically on the surface. Consequently, the firing with water for the purpose of achieving uniform cooling should also be able to adapt to these different situations.

The device according to US-A 5,325,694 attempts to simplify handling the device and to automate the control systems by designing a control loop which links the drop in the temperature of the block effected by cooling with the rate of block advancement. However, the sensors additionally required for this make the device not only more expensive, but also more susceptible to faults.

US-A 5,337,768 describes another embodiment for regulating such a device, which however exhibits the same principle disadvantages as the aforementioned US-A 5,325,694.

The invention is based on the object of providing methods for heat treating metallic extrusion billets or rod portions before they are fed into the extruder, as well as devices for performing said method, in which the aforementioned disadvantages do not occur. In particular, it is the intention to propose methods and devices which enable a heat treatment consisting of reheating and cooling which is very fast and at the same time very precise in guiding the temperature.

This is achieved by the features of the respective main claims, while expedient variants of these methods and devices are defined by the corresponding sub-claims.

In extrusion processes, in particular of light metal alloys, it is important for achieving high productivity that the entire line or billet is pressed at the highest possible rate while maintaining a particular and optimum exit temperature of the line or billet. To achieve this aim, different initial temperatures of the block are required, depending on the profile shape and instrument - i.e. the degree of deformation - and on the desired rate of extrusion, which for reasons of productivity should be as high as possible - i.e. depending on the deformation capacity. In direct-operation extruders, such as are conventionally used for light metal alloys, it is additionally important that the block exhibits a temperature profile which falls off in the extrusion direction - a so-called "temperature taper" - at the beginning of the extrusion process. As has long been known as prior art, this temperature taper is required in order to equalize the input, increasing from the beginning of the block to the end of the block, of mechanical energy which is converted in the course of the extrusion process into heat, such that the extrusion process can nonetheless run isothermally. The more precisely this temperature taper is adjusted to the respective extrusion conditions, the higher the rate of extrusion which may be selected and the higher the productivity.

In accordance with the invention, extrusion billets or rods - i.e. blocks - are first heated as quickly as possible to an extrusion temperature which is as high as possible, depending on the respective material, wherein the temperature in the block is uniformly distributed to a very small temperature tolerance after being heated. For light metal alloys, for example, a temperature tolerance of less than ±10K, e.g. ±5K for block diameters of 250mm to 300mm, is typical.

After said heating, it is advantageous - particularly in high-production extrusion - to cool the block as quickly as possible using water in a rapid cooling means, such that once the block has been rapidly cooled and the temperature equalized as a result of thermal conduction dependent on the material of the block, the block exhibits - with the desired, narrow tolerance - the initial temperature on the side of the block facing the instrument which is optimal for the respective extrusion instrument - i.e. the respective shape of the profile - and for the

respectively desired rate of extrusion which for reasons of productivity is as high as possible, as well as the respectively optimal distribution of said temperature along the length of the block. An active cooling period of about 30 seconds is typical for cooling as quickly as possible, followed by a period of time for equalizing the temperature by thermal conduction, which principally takes place over the cross-section of the block, this period of time typically being longer than the active cooling period. After the rapid cooling, the block is fed into the extruder and pressed. The transfer time required for this is taken into account when determining the period of time for the temperature to equalize as a result of thermal conduction.

As opposed to the prior art, the method in accordance with the invention allows the block to be provided with exactly the respectively required temperature and/or temperature distribution, and with the necessary small temperature tolerance.

When pressing light metal alloys which may be heavily extruded, e.g. alloys with the numbers 7xxx and 2xxx, for which indirect-operation extruders are conventionally used in order to rule out the frictional influence of the recipient wall, it is advantageous for the block to exhibit a temperature at its beginning which is defined higher than the extrusion temperature, distributed as uniformly as possible, in the remaining block. This is also simply possible with the method in accordance with the invention, since alongside a uniform temperature distribution, localized differences in temperature along the length of the block, e.g. a higher temperature at the beginning of the block only, can also be generated.

A further advantage of the method in accordance with the invention is suitability for high-production extrusion. If the cooling period and temperature equalization period are longer than the extrusion cycle, the so-called time per block, then two cooling means can be operated in parallel, such that each block can individually undergo the necessary cooling period and equalization period, independent of the time per block, even if the two periods of time added together are longer than the time per block.

The method in accordance with the invention also exhibits crucial advantages over the prior art in the event of unintended interruptions in extrusion, the consequences of which are all the more serious, the higher the productivity of the extruder is. In accordance with the invention, rapid heating by means of direct firing during the first part of the heating process is combined with convectional heating in the final part of the process. By suitably selecting the gas temperature, any overheating of the material during said convectional heating may be ruled out, even if extrusion is interrupted and the block transport is consequently brought to a stop. As soon as the extruder is operational again, a block having the correct extrusion temperature is immediately available.

This substantial advantage in accordance with the invention is achieved alone by the fact that in accordance with the invention, a rapid heating means using direct firing in accordance with the prior art is combined with convectional secondary heating in which the temperature is also equalized. Because of the lower cost of conventional burners as compared to recuperation burners to be particularly advantageously used, this solution requires a somewhat lower expenditure of costs. The main advantage of this simple solution, however, is that it is suitable for retro-fittings for performing the method in accordance with the invention, by simply adding at least one convectional heating zone to an existing rapid heating plant using direct firing.

A substantial advantage relating to production costs is the exceedingly low gas consumption as compared to plants in accordance with the prior art, which is achieved by advantageously using burners comprising an integrated exhaust gas recuperator for preheating the combustion air. Alongside this advantage in costs, the use of recuperation burners comprising integrated preheating of the combustion air is also greatly advantageous in a control-engineering sense, since preheating the combustion air and operating the burners are directly linked to each other. In plants in accordance with the prior art, by contrast, the exhaust gas of all the burners is collected, removed at one location - conventionally the beginning of the firing zone - and supplied to a central heat exchanger for

preheating the combustion air. Due to the exhaust gas being centrally removed, a longitudinal flow arises in the oven which negatively influences the temperature regulating behavior of the individual zones. When the door on the exit side of the heating means is opened to remove a block, cold air can even enter the oven if the exhaust gas is continuously removed, which in turn influences the temperature distribution in the column of material as well as negatively influencing temperature regulation. In the method in accordance with the invention, and using the heating device in accordance with the invention, the use of recuperation burners comprising exhaust gas ducts means that exhaust gas is only removed in the same or almost the same quantity as the combustion gas generated if the respective burner is actually switched on.

In addition to said advantage in the control-engineering sense, another advantage also results with regard to an improvement in heat transfer. The recuperation burners are operated at a very high firing exit velocity. This forms a jet which swirls around the block with force and ensures an increase in convectional heat transfer, even without using a particular flow drive. In addition, the induction effect of the burner jet of high impetus also circulates the hot exhaust gas present in the heating device, which in turn increases convectional heat transfer.

There further exists the possibility, using the method in accordance with the invention which provides recuperation burners for heating, of also employing such recuperation burners which use flameless oxidation at correspondingly high internal oven space temperatures, in a so-called flox mode. Flameless oxidation means that gas, exhaust gas and combustion gas are mixed in the burner such that no flame is visible and the oxidation releasing the heat energy takes place so to speak in the burner jet. This has crucial advantages for the uniformity of heat transfer on the block surface.

The aforementioned recuperation burners, also partially suitable for flox operation, are described in DE 34 22 221 4, EP 0 463 218 B1, EP 0 685 683 B1 and DE 195 41 922 C2.

Lastly, using recuperation burners in accordance with the invention also shortens the required length of the plant as compared to a plant of the same capacity in accordance with the prior art. The reason for this is that the preheating zone required in plants in accordance with the prior art, in order to recuperate a part of the heat of the exhaust gas, is omitted. This shorter construction length at greater capacity means not only a saving of space but is also from the standpoint of process technology advantageous, since the column of blocks contained in the plant is shorter, which substantially simplifies operating the plant with different alloys.

In summary, therefore, the method in accordance with the invention exhibits the following advantages with regard to heating:

1. subdividing heating into rapid heating by means of direct firing, in the front part of the heating device only, whereas at the end of the heating device heat is transferred convectionally (by convection). This combines the high rate of heating of direct firing with the uniform heating, without the danger of localized overheating, of convectional heating.

2. the possibility of retro-fitting an existing rapid heating plant using direct firing, by adding at least one convectional zone at the end of the existing heating device.

3. using recuperation burners comprising integrated fresh air preheating. This improves the regulating behavior of the heating device and in addition significantly reduces the consumption of fuel. Reducing the length of the plant by omitting the preheating zone.

4. the possibility of using burners to operate using flameless oxidation and therefore of uniformity of the transfer of heat in direct burner jet firing.

The cooling method in accordance with the invention and the device for performing this method exhibit further advantages. Unlike in the prior art, a block is not passed through a cooling ring in the longitudinal direction, rather a block held on its facing sides is fed as a whole into a stationary cooling means. It is cooled by means of an annular arrangement of individual nozzles which during the cooling process are situated in a precisely defined, fixed position with respect to the block. The desired, necessary cooling effect, for achieving the required temperature or temperature distribution, is achieved by operating said individual nozzles arranged in rings at different pressures and/or with different activation times. The expenditure for control systems and handling is substantially lower than for devices in accordance with the prior art; moreover, the precision with regard to the temperature and temperature distribution to be reached is higher than in known devices and methods.

The invention will now be illustrated in more detail by way of example embodiments and by referring to the enclosed schematic drawings, which show:

Figure 1	the course of temperature over time for a block, from the beginning of rapid heating, through rapid cooling, to being fed into the extruder;
Figure 2	the arrangement of individual aggregates for performing the heat treatment in accordance with the invention;
Figure 3	a schematic representation of a device in accordance with the invention for performing rapid heating, with sectional representations of the sequentially arranged parts of the device, the material being heated using direct firing in accordance with the prior art;
Figure 4	a flow chart of the plant shown in Figure 3 for performing rapid heating;
Figure 5	another embodiment in accordance with the invention of the zone of the device comprising direct firing, using recuperation burners;
Figure 6	advantageous nozzles shapes for high-velocity recuperation burners;

Figure 7	a typical course of temperature in the individual parts of the heating device and in the material heated using the device;
Figure 8	the rapid cooling device in a schematically shown, simplified cross-section;
Figure 9	a schematically simplified longitudinal view of the rapid cooling device, in which the casing is shown in section;
Figure 10	a diagram comprising typical cooling curves for the measuring points indicated in the diagram, in the block to be cooled.

The method in accordance with the present invention is illustrated by Figure 1. Figure 1 schematically shows the course of temperature over time for a block, from the beginning of heating to being fed into the extruder. First, the block undergoes rapid heating within at most 20 minutes in the area of the device which in the example in Figure 1 uses direct firing by recuperation or recuperation-flox burners, such that there is no preheating zone for cooling the exhaust gas. Heating is concluded in at least one zone using convectional heat transfer with a comparatively small excess temperature. The temperature is also equalized here, for at most 3 minutes. The block is then fed to the cooling station. After the active cooling period of at most 30 seconds, the block passes through a temperature equalization period. In the final part of this equalization period, the block is fed to the extruder and, when isothermally extruded, exhibits a temperature difference between the end of the block and the beginning of the block.

Figure 2 shows schematically how the individual aggregates for performing the method in accordance with the invention are arranged. The extruder is schematically indicated by the reference numerals 2 and 3. 2 indicates the recipient into which the block 1 is inserted, and where it is pressed by the extrusion die 3 during the extrusion process. The extruding profile - or in instruments comprising a number of outlets, profiles (not shown) - are guided on the extrusion run-out 12. The block 1 is loaded into the extruder 2, 3 by a block loader 4 which is likewise only schematically indicated.

In the process flow direction 9, the block is first heated by direct firing in the front part of the heating device 7 and then for example in two sequentially arranged convectional zones 8a and 8b, the (in the process flow direction 9) last convectional zone 8b being operated at a lower gas temperature than the front zone 8a. The block proceeds from the heating device 7 to a transverse transport 5. The direction of movement is indicated by the arrow 10. From the transverse transport 5, the block is fed either into the cooling station 6a or into the cooling station 6b, so move in the direction of the movement arrow 11a or 11b. As already mentioned, more than one cooling station is useful if a plant works to a high productivity and with a short time per block.

The material 1, a column of individual billets or rods already cut off down the length (only hinted at in the figure for reasons of simplicity), is guided through the device via a transport means, for example a roller conveyor 20 as shown in Figure 3. If the rollers are not driven, the blocks are transported by pushing means outside the device. Other possibilities, not shown in the figures, include transporting the material 1 through the device by means of a lifting bar or a transport chain. Driven rollers or other ways of transport known from the prior art may also be used.

The first part of the device consists substantially of the firing area. As an example, Figure 3 shows two firing zones 7a, 7b. An entry zone 13 is situated before the first firing zone 7a in the direction of transport, and a separating zone 14 after the second (last) firing zone 7b. The separating zone 14 is followed by the first 8a of two convectional zones 8a, 8b; the final convectional zone (in the direction of transport) 8b, which is principally intended for temperature equalization, forms the end of the device. In the firing zones 7a, 7b, the material 1 is heated by flames generated by burner nozzles 15. In this way, the heat is substantially transferred from the surrounding oven space onto the material 1 by radiation. The exhaust gas of the burners is collected in the entry zone 13 and the separating zone 14 and diverted out of the device via exhaust gas conduits 16.

The convectional zones 8a, 8b each have a flow system containing at least one fan 17, at least one burner 22 for heating the heated gas and nozzles 18 arranged on the both sides of the material for blowing the material for the purpose of convectional heat transfer. The nozzles 18 are fed by the fan 17 via a system 19 of flow conduits, see Figure 3.

As becomes apparent from the flow chart according to Figure 4, the exhaust gas is guided through a heat exchanger 21 with which the combustion air for the gas burners is preheated. Recuperation burners 22 are expediently employed in the convectional zones 8a, 8b for heating, such that the exhaust gas cooled here by preheating the combustion air exits at the exhaust gas pieces of the burners.

A particularly advantageous embodiment of the firing zone is shown schematically in Figure 5. The blocks are heated by a smaller number of recuperation burners 22 as compared to the firing zone shown in Figure 3. The external heat exchanger 21 for preheating the combustion air is therefore omitted in this embodiment. Moreover, the recuperation burners used can be favorably embodied as high-velocity burners and/or high-velocity-flox burners which automatically switch from the normal combustion mode to the flox mode once the appropriate oven space temperature has been reached.

By favorably configuring the burner nozzle, the high-velocity burner jets can cover the material to be heated over a comparatively large area using the Coanda effect, as shown in Figure 5 by the schematic flow arrows 23. The axes of the burners and therefore of the flame jets 24 - or burner jets in the case of flox - can also be inclined towards the vertical direction to improve the flow coverage on the surface of the material. It is also possible to influence the burner jets 24 using nozzle orifices made of a material with high temperature stability, e.g. silicon carbide, to improve material coverage. Figure 6 shows such possible, advantageous examples of the nozzles of high-velocity burners. Figure 6a shows a burner nozzle which deforms the round burner jet into a fan jet; Figure 6b shows a burner nozzle in which the fan jet exhibits a partition in its center and the two

partial jets are correspondingly configured with a greater force than in Figure 6a. Figure 6c shows a burner nozzle having an exit cross-section like a "dog bone"; Figure 6d shows the cross-section of a burner nozzle which deflects the burner jet from the vertical. Figure 6e shows a burner nozzle which breaks the burner jet down into a number of - in the figure, three - individual jets, which hit the surface of the material in different directions. In this way, heat fluxes of 300 kW/m² and more can also be achieved over larger portions of the surface of the block.

The great advantage of the rapid heating device follows from the course of temperature for the core and the surface of the material 1, shown schematically in Figure 7. In the firing zones - in the example in Figure 7 two zones, F1 and F2, are assumed - the oven space temperature is extremely high, as also in the conventional firing zones according to the prior art. Since, however, these zones are now employed at the beginning of the device, there is no danger of overheating, and the spreading lay of the material temperature curve at various points in the material plays no part, since the temperature can be equalized in the subsequent convectional zones K1 and K2. In the second zone K2, the gas temperature (= oven space temperature) is finally in the range of the desired final temperature of the material. Thus, material overheating is ruled out in the device, even in the event of unplanned stoppages of the extruder and consequent interruptions in the transport of the material.

An advantageous example embodiment of a cooling device for cooling the block in accordance with the heat treatment method in accordance with the invention is described by way of Figures 8 to 10.

The block 1 is surrounded by groups of individual nozzles 25 arranged annularly around it in the longitudinal direction with gapping 26 adapted to the spraying image of the nozzles. The nozzles 25 of a group of nozzles are here connected to each other by a supply pipe 27. A supply pipe 27 is supplied with the cooling fluid by a supply pipe 28 for a group of nozzles. Water is used as the cooling fluid, which can be prepared in a particular way - e.g. demineralized - as necessary. In

the middle of the central supply pipe 29, into which the pump (not shown) conveys, there is situated an obturator 30 operated by the control systems, and a pressure regulator valve 31 which can be adjusted either by control systems or manually. A water basin 32 is situated underneath the block 1, from which the pump (not shown) conveys the cooling fluid back into the central supply conduit 29 via a suction conduit 33. In accordance with the general prior art, a filter unit and a heat exchanger for removing the heat removed from the block by the cooling fluid are also installed in this circuit. Instead of the back conveying pump, a downpipe can also be used if a water tank can be positioned underneath the cooling device with the appropriate difference in height.

Instead of a pump, a pressure accumulator - e.g. an elevated water tank - can also be used to supply the spray nozzles 25.

The block 1 is held on both facing sides by a clamp mounting 34, see Figure 9. The clamp mounting 34 consists, similar to a screw clamp, of a fixed part 34a and a moving part 34b, the moving part being drawn towards the fixed part, e.g. by means of cylinders 35. Both pneumatic cylinders and hydraulic cylinders may be used. In addition, the clamp mounting 34 is embodied such that a catch 34c prevents the block from dropping down. A linear guide 36 serves to guide the moving part 34b of the clamp mounting 34. This linear guide is firmly connected to guiding rails 37 which may be shifted in the longitudinal direction of the block into guiding rollers 38. This shifting movement provides the inward and outward movement of the block received from the loading/unloading position 39 by the clamp mounting. As also with clamping, the shifting movement can be achieved pneumatically or hydraulically by means of cylinders 45 or using another linear drive output, e.g. by means of a chain drive, spindle or toothed rack.

The block proceeds to the loading/unloading position using a transverse travelling means 40 which inserts the block 1 into the open clamp mounting 34. Using the clamp mounting 34, it is possible to clamp blocks of different lengths. In this way, the instrument side of the block always abuts the fixed clamp mounting 34a, such

that there is a clear correspondence between the temperature profile and the block. The possibility of clamping blocks of different lengths is indicated in Figure 9 by the position 34b of the moving clamp mounting shown by a dashed line.

The spraying area of the device is enclosed by a casing 41 which can be easily removed. On its loading/unloading side, the casing has a door, e.g. a lifting door 42. It is advantageous to generate a partial vacuum in the casing, e.g. using an appropriately dimensioned fan, by directing exhaust air outwards out of the casing, e.g. via the cover. This reliably prevents moisture and vapor from entering the installation space and therefore the working area of the extruder. The whole device is supported by a profile steel frame 43 which can be positioned on the level shop floor.

Deviating from this described block mounting, it is also possible to use known mountings for the block such as are known from block brushing machines.

The angular gapping of the individual nozzles 25 is set according to their spray image. In general, a gapping angle of 45° is sufficient. This gapping angle allows the linear guide 36 to be easily arranged without compromising the spray image of the nozzles on the surface of the block.

The groups of nozzles can be individually activated with the aid of the obturators operated by the control systems. The corresponding control valve 31 allows the nozzle pressure desired for each group of nozzles to be individually set. Expediently, the control valves 31 are set and the obturators activated by means of a process control system. For a cooling process in which the block 1 is both to be cooled as a whole and is also to acquire a "temperature taper", all the groups of nozzles are initially switched on at the same time. After an interval of time sufficient for the cooling as a whole, the groups of nozzles are switched off in sequence, beginning on the instrument side of the block, such that the total cooling time increases from the beginning of the block (the instrument side) to the end of the block (the extrusion die side). The greater the difference in time

between switching off the groups of nozzles at the beginning of the block and at the end of the block, the greater the temperature difference along the length of the block and the more marked the "temperature taper".

The clamp mounting 34 used for the block 1 in accordance with the invention and which grips the facing sides of the block ensures that the surface of the block is covered uniformly by the cooling fluid and not compromised by any bearing supports. The clamp mounting also screens the facing sides of the block, such that the heat in the block 1 flows almost radially even at the ends, and the temperature distribution provided by the cooling is not disrupted by end effects on the facing sides. Uniform covering with the cooling fluid, here water, ensures uniform cooling of the temperatures of the block surface in the area of interest, above the Leidenfrost temperature in the area of stable film vaporization, heat transfer on a plane surface depends substantially only on the water firing density. The influence on the cooling effect of different orientations of the cylindrical surface of the block - horizontal for cooling the upper face of the block from above, vertical for the two sides and horizontal for cooling the lower face from beneath - can be compensated for when using individual nozzles in accordance with the invention by appropriately selecting spray nozzles of different sizes, preferably of the same type.

Figure 10 shows typical cooling curves for various measuring points in a block. The positions of the measuring points 1 to 12 are illustrated in the sketches in the figure. The digits indicated on the curves relate to the numbers of the temperature measuring points. It can be seen that after a cooling period of about 18 seconds and an equalization period, following the cooling period, of about 60 seconds, the desired "temperature taper" of about 10 K per 100mm of the length of the block is set, and the temperature is also equalized over the cross-section of the block to about 20 K at most. This temperature equalization continues further during the period of time of about 25 seconds which elapses up until the beginning of extrusion and which is necessary for moving and positioning the block, such that both the desired cooling and the desired "temperature taper" are at hand, with

high, reproducible precision, during the extrusion process. Since cooling provided by the cooling device in accordance with the invention serves in particular to increase the rate of extrusion and therefore of production, short times per block of 60 seconds or less may be achieved. For such short times per block, it is therefore useful to operate more than one of the cooling means described in accordance with the invention in parallel, such that a sufficient period of time is still available for the desired temperature equalization over the cross-section of the block, despite the short time per block.

The cooling device in accordance with the invention, in a fixed position with varying cooling periods along the length of the block, thus uses the known physical property of temperature equalization processes, which run slower to the power of 2 with increasing distance between points having the same temperature difference, and thus substantially faster in the radial direction than in the axial direction.